tioned), and from these three functions are found the magnitudes of the two principal forces of compression or tension, and the angle which one of them makes with y, in a form admitting of numerical calculation.

The author then applies the theory to six cases, namely, (1) a beam projecting from a wall; (2) a beam supported at its ends; (3) a beam supported at its ends and carrying a load on its center; (4) a beam supported at its ends and carrying an excentric load; (5) a beam strained at both ends by the connexion of other beams, in the manner of the tubes of the Britannia Bridge; (6) a beam strained at one end only. Cases (3) and (4) require the use of discontinuous functions. Tables are given, exhibiting the numerical magnitudes of the two principal forces and the angle made by one of them with y, for 121 points in case (1), and for 231 points in each of the other cases. By means of these numbers, diagrams are formed, exhibiting in each case the directions of the lines of compression-thrust and tension-pull in every part of the beam.

III. "Photochemical Researches.—Part V. On the Measurement of the Chemical Action of Direct and Diffuse Sunlight." By R. W. Bunsen, For. M.R.S., and H. E. Roscoe, B.A. Received November 11, 1862.

(Abstract.)

In one of the four communications which the authors have already had the honour of presenting to the Royal Society on the subject of the measurement of the chemical action of light, the attempt was made to determine experimentally the laws regulating the distribution of the chemical action of the sunlight and diffuse daylight on the surface of the earth when the sky is perfectly unclouded and the atmosphere clear. The methods of measurement there employed do not, unfortunately, apply to the much more usually occurring case of cloudy skies and hazy atmosphere. The aim of the present communication is to describe an entirely different mode of measuring the chemical action effected at any point on the earth's surface by the total sunlight and diffuse daylight, under the most widely varying conditions of situation, climate, and state of the atmosphere.

In spite of the various futile attempts which have been made to register and measure the chemical action of light by means of photographic tints, it still appeared possible in this way to attain the desired end. No instruments founded on such a mode of measurement can yield reliable results unless we know the conditions under which photographic surfaces of a constant degree of sensitiveness can be obtained, and unless the relations be determined which exist between the degree of tint produced, and the time and intensity of the light acting to effect such a tint.

The first point which the authors examine, is whether the photographic tints produced vary in shade in the direct ratio of the intensities of the acting light. Several experiments proved that no direct ratio between the degree of blackening and the intensities of the light exists. Hence it is necessary to relinquish the idea of employing any mode of measurement founded on the comparison of photographic tints of different shades. The next point examined is whether equal shades of blackness always correspond to equal products of the intensities of the acting light into the times of insolation. For the purpose of testing the truth of this proposition, an instrument is employed by which photographic sensitized paper can be exposed for times which can be exactly measured to within small fractions of a second. This instrument consists essentially of a pendulum vibrating about $\frac{3}{4}$ seconds, by whose oscillation a sheet of darkened mica is withdrawn from, and brought back over, a horizontal strip of paper prepared with chloride of silver, and fixed in a constant position relative to the pendulum and sheet of mica. The time during which each point in the length of the strip is exposed is different, and the time of insolation for each point can be calculated when the length and position of the strip, and the duration and amplitude of the pendulum's vibration are given. A Table exhibits for each millimetre in length of the strip, as measured by a scale attached, the time of exposure in seconds which the corresponding point of the strip undergoes in one vibration of the pendulum. These numbers require to be multiplied by n if the paper has been insolated for n vibrations.

The paper insolated whilst the pendulum is oscillating, exhibits throughout its length a regularly diminishing shade from dark to white; and the time of insolation of any point is found by reference

to the Table. If we wish to determine which of these shades corresponds to another tint produced by a separate insolation, we cannot make the comparison by daylight or ordinary lamp-light, as these lights produce considerable changes of tint in the sensitive paper. The two shades may, however, be perfectly and safely compared by the light of a bright soda-flame; this light possesses the great advantage of being chemically inactive, and likewise of rendering imperceptible those slight differences of colour which make the comparison of two shades by the ordinary light so difficult.

In order to compare any other photographic tint with the point of equal shade on a strip, the latter, together with its millimetre scale, is attached to a board, in a darkened room. The board slides in a groove, so that it can be moved horizontally; and in front of the paper strip a small block holds in a fixed position a small piece of the tinted paper which it is desired to compare. On throwing the light of a bright soda-flame upon both surfaces it is easy, by moving the board from side to side, to find the exact point at which the shade of the strip is identical to that of the other tinted paper. It is then only necessary to consult the Table in order to find the time in seconds during which the paper must have been exposed in order that it should attain the tint in question. A series of lights of known intensities was obtained, by allowing the sun to shine through holes of known size. The images thus formed fell on to a piece of prepared paper; and the tints produced were compared with a strip darkened in the pendulum-apparatus, and thus the time of exposure necessary to effect the shade determined. Experiments made with intensities varying from 1 to 50, show that within these limits equal shades of blackness correspond to equal products of the intensities of the acting light into the times of exposure; so that the light 1 acting for the time 50, produced the same degree of blackening as the light 50 acting for the time 1.

A method for measuring the chemical action of light by simple observations is then founded upon this proposition. Thus, if we assume as the unit of photochemical action that intensity of light which produces in the unit of time a given degree of shade, we have only to determine, on a strip of paper tinted in the pendulum-apparatus, the point where the shade of the strip coincides with the given tint; the reciprocals of the times which correspond to these

points of equal shade give the intensities of the light expressed in terms of the above unit.

This method of measurement is available only—

1. If the phenomena of photochemical induction do not interfere with the blackening of the paper.

2. If a photographic surface of a constant degree of sensitiveness can be prepared.

3. If an unchangeable tint can be obtained which can be exactly compared with the photographic paper.

The result of a series of experiments made by varying the number of the vibrations and calculating the intensity from each observation, showed that photochemical induction does not exert any prejudicial effect upon the measurements.

The question into which the authors enter at greatest length as being the most important for determining the exactitude of the measurements, relates to the mode of preparing a standard paper possessing a constant degree of sensitiveness. The relative degree of sensitiveness is determined by exposing the papers to one and the same light for the same length of time, and then comparing their tints with the shades of a strip prepared in the pendulum-apparatus, fixed in a solution of hyposulphite of soda, and furnished with an arbitrary scale. The influence of the strength of the nitrate-of-silver solution upon the sensitiveness is first examined; a series of experiments shows that with the same homogeneously salted paper, the sensitiveness of the film does not alter when the strength of the silver solution varies from 8 to 10 or 12 parts of nitrate of silver to 100 of water. Further examination showed that the time during which the paper lies upon the surface of the silver bath may vary from 15 seconds to 8 minutes, without any difference in the sensitiveness of the paper being noticed; and no difference is found by the employment of silver solutions which had been long in use and those freshly prepared. The papers thus silvered may be preserved for from 12 to 15 hours in the dark without undergoing any change in their sensitiveness.

If the paper be allowed to float on the surface of the solution of chloride of sodium as on that of the silver bath, the sheet after silvering exhibits, on drying, a very unequal degree of sensitiveness in its various parts. If, on the contrary, the sheet be well soaked in the

salt-bath no such irregularity appears, and the sheet is of an equal degree of sensitiveness throughout its whole surface. This fact is determined by several extended series of experiments. The effect of change of concentration of the salt-bath upon the sensitiveness of the film is very great; and, as far as the observations extend, no limit exists beyond which an increase or a diminution of the percentage of salt in solution ceases to affect the sensitiveness of the film. Hence, in order to obtain constant results it is necessary to employ a solution of chloride of sodium of constant strength. By using solutions of the same strength, papers of a constant degree of sensitiveness are obtained.

The influence of the thickness of the paper employed is next examined. Experiment shows that differences in the thickness of white paper, such as is usually employed for photographic purposes, is without influence upon the sensitiveness of the film of chloride of silver.

The changes in atmospheric temperature, from 3° C. to 50° C., and in atmospheric moisture are likewise found not to influence the sensitiveness of the prepared paper.

From the experimental results detailed in the communication, it appears that by adhering to a certain mode of preparation, a standard paper can be obtained, which at all times possesses a degree of sensitiveness sufficiently constant for the purposes of exact measurement. In the following extract from a larger Table, the readings are given which were made from papers prepared in three different salt solutions of the strengths mentioned, and silvered in a solution containing 12 of nitrate of silver to 100 of water. Equality in the numbers in each of the columns III. and IV. denotes equality in the readings and in the tint, and therefore equality in the sensitiveness of the prepared surfaces. Three sheets of paper were dipped into each solution. These numbers likewise show the great degree of accuracy with which tints can thus be compared.

I. Paper.	II. Na Cl to 100 parts of water.	III. Intensity No. 1.	IV. Intensity No. 2.
Upper part of sheet No. 2 ...	3·026	87·0	75·4
Middle part of sheet No. 3 ...	2·950	86·3	74·4
Middle part of sheet No. 2 ...	3·028	86·0	74·9
Lower part of sheet No. 2 ...	3·000	85·9	74·4

The next subject considered is the preparation of an unvarying tint which can be easily obtained and used as the standard of comparison. This is effected by grinding together 1000 parts of pure oxide of zinc with 1 part of pure lamp-black. A series of experiments showed that a colour can thus be prepared which possesses a constant and unalterable shade; and this can be used as a measure of the standard tint.

Having proved that a standard photographic paper of constant sensitiveness, and a standard tint of unvarying shade can be prepared, it is only necessary to apply the proposition that equal products of the intensities of the light into the times of insolation effect equal shades of blackness, in order to found a method of comparative measurement of the chemical action of the total daylight. As the *unit* of measurement, the authors propose to adopt that intensity of the light which in one second produces the standard tint of blackness upon the standard paper.

When the standard paper is insolated in the pendulum-apparatus, a strip is obtained which is tinted with every gradation of shade from dark to white. If the point on this strip is determined which coincides in shade with a paper covered with the standard tint, we have only to look into the Table to obtain the time of insolation (t), in seconds, which is necessary to produce the shade corresponding to the reading on the millimetre scale. If this time of insolation were found to be one second, the intensity of the light then acting would be $I=1$; for any other time the intensity of the chemical rays would be $\frac{1}{t}$.

As an example of such measurement, the authors append three series of observations, giving the total amount of chemically active rays falling on a horizontal surface at Manchester in summer and winter, made at intervals of 10 minutes throughout three separate days. These observations are likewise graphically represented as curves, which show maxima and minima exactly corresponding to the appearance and disappearance of the sun; and from them some idea may be formed of the vast differences which occur in the intensity of the chemical rays falling on the earth's surface during the longest and the shortest days.

In conclusion the authors state that it is possible, by using the

pendulum-apparatus, to construct a portable instrument by means of which a large number of observations can be made upon a few square inches of paper. They reserve the description of their instrument for a future occasion.

IV. "Notes of Researches on the Poly-Ammonias.—No. XXI. On Paraniline." By A. W. Hofmann, LL.D., F.R.S. Received December 2, 1862.

In a short paper submitted to the Royal Society about a year ago *, I called attention to some of the by-products which are obtained in the manufacture of aniline upon a large scale, and more especially to toluylene-diamine, the primary diamine of the toluyl-series.

MM. Collin and Coblenz, aniline manufacturers at Labriche, near St. Denis, Paris, to whose kindness I had been indebted for the material used in these researches, immediately after their publication transmitted to me with the utmost liberality a large quantity of basic oils boiling at temperatures higher than the boiling-point of aniline, which are separated from the pure aniline by rectification, and are known in the language of the laboratory as *queues d'aniline*. The investigation of this complex mixture has been interrupted by numerous engagements arising from the International Exhibition; and it was only within the last two months that I was enabled to resume the inquiry.

This inquiry is far from being finished; but some of the results already obtained are sufficiently definite for publication.

Submitted to distillation, the *queues d'aniline* begin to boil at about 182°, considerable quantities of pure aniline passing over; the temperature gradually rises without any indication of a fixed boiling-point, until it becomes necessary to remove the thermometer; in fact the last bases are volatilized only at temperatures not very far short of a red heat. By collecting separately what distils between 200° and 220°, and again what comes over between 270° and 290°, basic oils are obtained from which, by appropriate treatment, very considerable quantities, respectively, of toluylamine (toluidine) and toluylene-diamine may be separated. The former of these bases more

* Proceedings, vol. xi. p. 518.